

#### **401 KAR 48:080. Liner and cap design requirements for contained landfills.**

RELATES TO: KRS 224.01, 224.10, 224.40, 224.43, 224.99

STATUTORY AUTHORITY: KRS 224.10-100, 224.40-305

NECESSITY, FUNCTION, AND CONFORMITY: KRS Chapter 224 requires the cabinet to adopt rules and administrative regulations for the managing, processing, or disposal of solid wastes. KRS 224.40-305 requires that persons engaging in the managing, processing, or disposal of waste obtain a permit. This chapter establishes the minimum technical standards for solid waste sites or facilities. This administrative regulation sets forth the liner and cap design requirements for contained landfills.

Section 1. Liners for Contained Landfills. At a minimum all contained landfills shall have:

- (1) A primary composite liner as specified in Sections 2 and 7 of this administrative regulation; and
- (2) A secondary composite liner that:
  - (a) Meets the secondary liner criteria specified in Sections 2 and 7 of this administrative regulation; or
  - (b) Is a naturally occurring material provided that such natural material:
    1. Shall be equivalent to material with a minimum thickness of twenty (20) feet with a maximum permeability of  $1 \times 10^{-7}$  centimeters per second;
    2. Shall lie above the uppermost aquifer; and
    3. Shall continuously underlie the landfill site or facility and be demonstrated to have sufficient integrity to protect the uppermost aquifer from contamination in the event of a breach of the primary composite liner.

Section 2. Components of Contained Landfill Liner Systems. Once the subgrade is established, the primary and secondary liner systems shall consist of the layers, listed in subsections (1) through (3) of this section.

- (1) The secondary liner system shall consist of the following layers, listed from bottom to top:
  - (a) A twelve (12) inch soil layer with a permeability of  $1 \times 10^{-7}$  centimeters per second as specified in Section 4 of this administrative regulation;
  - (b) A secondary synthetic liner as specified in Section 5 of this administrative regulation;
  - (c) A twelve (12) inch drainage layer with a permeability of  $1 \times 10^{-3}$  centimeters per second; and
  - (d) A filter fabric or other material approved by the cabinet.
- (2) The secondary liner layer specified in subsection (1)(a) and (b) of this section may be substituted for by a naturally occurring material as specified in Section 1(2) of this administrative regulation.
- (3) The primary liner shall consist of the following layers, listed from bottom to top:
  - (a) A thirty-six (36) inch clay layer with a permeability of  $1 \times 10^{-7}$  centimeters per second as specified in Sections 4, 6 and 7 of this administrative regulation;
  - (b) A primary synthetic liner as specified in Section 5 of this administrative regulation;
  - (c) A twelve (12) inch drainage layer with permeability of  $1 \times 10^{-2}$  centimeters per second or a layer of equivalent performance as specified in Section 6 of this administrative regulation; and
  - (d) A filter fabric or other material approved by the cabinet to protect the integrity of the drainage layer.

Section 3. Specific Landfill Subgrade Requirement. The landfill subgrade is the uppermost in situ rock layer, in situ soil layer or select fill that shall be graded and prepared for landfill construction. For lateral expansions adjacent to existing landfills, the cabinet may approve encroachment upon the existing landfill's side slope if a leachate barrier system is designed and construction to intercept

leachate and prevent its migration into the existing landfill.

(1) Materials required. The landfill subgrade material shall be free of organic material and consist of bedrock, on-site soils, or any select fill with the structural ability to support the landfill maximum load with a factor of safety of two (2.0).

(2) Construction requirements. The landfill subgrade shall be graded in accordance with the requirements of the approved engineering plans, report, and specifications. The material shall be sufficiently dry and structurally sound to ensure that the first lift and all succeeding lifts of soil placed over the landfill subgrade can be adequately compacted to the design requirements.

(3) Certification requirements. At a minimum, the subgrade surface shall be inspected in accordance with the following requirements:

(a) Before placing any material over the subgrade, the project engineer shall visually inspect the exposed surface to evaluate the suitability of the subgrade and ensure that the surface is properly compacted, smooth, uniform, and has positive surface drainage;

(b) Soil subgrade shall be proof-rolled using a minimum 100,000 pound loaded four (4) tire scraper (twenty (20) cubic yard size) or equivalent procedure and equipment approved by the cabinet;

(c) Soil subgrade shall be tested for density and moisture content at a minimum frequency of nine (9) tests per acre. The subgrade shall be compacted to a density of at least ninety (90) percent of the standard proctor; and

(d) Sufficient cross sections shall be taken showing the finished elevation of the completed subgrade, referenced to existing site control. These cross sections shall serve as documentation and reference data for all future volume calculations.

Section 4. Specific Soil Component Requirements of Landfill Liner Systems. The soil component of the landfill liner system shall be a continuous layer of low permeability soil constructed to control fluid migration.

(1) Low permeability soil components shall have a maximum remolded coefficient of permeability of  $1 \times 10^{-7}$  centimeters per second. The soil shall be placed without damaging any collection and removal system components. The soil material shall be substantially free of tree roots, wood or other decayable materials and large rock. The soils shall be compacted to a minimum of ninety-two (92) percent of the standard proctor density.

(2) Construction requirements. The project engineer shall ensure that the soil component of the liner system installation conforms to the following minimum requirements:

(a) The soil component of the liner system shall be placed on a slope of no less than three (3) percent toward the main leachate collection line and one (1) percent along the main leachate collection line to promote positive drainage across the liner surface and at a maximum slope not greater than fifty (50) percent.

(b) Compaction shall be performed by properly controlling the moisture content, lift thickness, and other necessary details to obtain the density, moisture and permeability characteristics specified in 401 KAR Chapter 48. The maximum final compacted thickness of each lift of soil material shall be six (6) inches or the thickness necessary to protect the integrity of underlying components and achieve the required liner performance standards.

(c) During construction the moisture content of the soil component of the liner system shall be maintained within the range identified in accordance with the certification requirements to ensure that the remolded lift attains the required permeability.

(3) Certification requirements. The project engineer shall include in the construction certification report a discussion of all required quality assurance and quality control testing. The testing procedures and protocols shall be submitted and approved by the cabinet. The results of all testing shall be included in the construction certification report including documentation of any failed test results, descriptions of the procedures used to correct the improperly installed material, and statements of all

retesting performed in accordance with the following requirements:

(a) The project engineer shall certify the results of the quality control testing of any soil liner materials. The intent of the quality control testing is to ensure that the specified material meets the permeability requirements of subsection (1) of this section. Before and during construction of the soil component of the liner system, the following minimum testing and classification shall be performed:

1. Determination of the classification of soils for engineering purposes using test methods approved by the cabinet for each 10,000 cubic yards of soil material placed and each time significant soil material changes are noted:

2. One (1) analysis of soil particle size for every 2,000 cubic yards of soil liner material placed from the same source. Additional analyses shall be performed if the source of material is changed or if a different soil type is encountered from the same source.

3. One (1) Atterberg limits analysis of plastic and liquid limit and plasticity index as approved by the cabinet for every 2,000 cubic yards of soil liner material placed;

4. One (1) moisture content test for every 2,000 cubic yards of material placed; and

5. A minimum of one (1) comparison of the moisture-density-permeability relation for every 20,000 cubic yards of material placed and one (1) each time soil material changes are noted. A minimum of three (3) laboratory permeability tests shall be performed using a triaxial cell with backpressure. The specimen used for each permeability test shall be remolded at the same moisture content which shall be equal to or not greater than four (4) percent above the optimum moisture content. The comparison shall be based on a semilog plot of percent maximum density versus permeability with at least one (1) point below and one (1) point above the target permeability value.

(b) Quality assurance testing included in this paragraph shall be compared to and evaluated against the quality control testing of paragraph (a) of this subsection where applicable. Quality assurance testing shall include:

1. At least nine (9) density tests per acre per lift of soil material placed;

2. A minimum of nine (9) moisture content tests per acre per lift of soil material placed; and

3. All moisture-density testing performed using nuclear methods.

**Section 5. Specific Synthetic Liner Requirements.** A synthetic liner is a low permeability manmade material having a maximum coefficient of permeability of  $1 \times 10^{-12}$  centimeters per second and is used to control fluid migration from landfills.

(1) **Materials required.** The synthetic liner material shall have a demonstrated hydraulic conductivity less than  $1 \times 10^{-12}$  centimeters per second and chemical and physical resistance not adversely affected by waste placement or leachate generated and a maximum water vapor transmission rate of 0.04 grams per square meter per day for forty (40) mil nominal thickness material and 0.03 grams per square meter per day for sixty (60) mil nominal thickness material. Documentation shall be submitted to ensure chemical compatibility of the synthetic liner material chosen or, in absence of the appropriate documentation, chemical compatibility testing shall be performed using a test method acceptable to the cabinet.

(2) **Construction requirements.** Synthetic liners shall be installed in accordance with the requirements of the approved engineering plans, report, and specifications and manufacturer's recommendations. The project engineer shall ensure that the synthetic liner installation, at a minimum, shall conform with the following:

(a) The synthetic liner shall have a nominal thickness of sixty (60) mils;

(b) The synthetic liner shall be installed on a subgrade that has a minimum three (3) percent slope to promote positive drainage;

(c) Synthetic liners installed on slopes greater than twenty-five (25) percent shall be designed to withstand the calculated tensile forces acting upon the synthetic material, and shall ensure that overall slope stability is maintained;

(d) The surface of the supporting soil above which the synthetic liner shall be installed shall be reasonably free of stones, organic matter, irregularities, protrusions, loose soil, and any abrupt changes in grade that may damage the synthetic liner. The supporting soil shall conform to the requirements of Section 4 of this administrative regulation;

(e) The anchor trench shall be excavated to the length and width prescribed on the approved design drawings;

(f) Field seams shall be oriented parallel to the line of maximum slope, i.e., oriented along, not across the slope. In corners and irregularly-shaped locations, the number of field seams shall be minimized;

(g) The materials shall be seamed using an appropriate method acceptable to the cabinet. Seam testing shall be in accordance with the requirements of subsection (3) of this section;

(h) The seam area shall be free of moisture, dust, dirt, debris, and foreign material of any kind before seaming; and

(i) Field seaming shall be prohibited when the conditions including ambient air, temperature, precipitation, and wind do not meet the engineers recommendations based upon the suppliers specifications.

(3) Certification requirements. The project engineer shall include in the construction certification report a discussion of the approved data resulting from the quality assurance and quality control testing required in this paragraph. The results of all testing shall be included in the construction certification report including documentation of any failed test results, descriptions of the procedures used to correct the failed material, and statements of all retesting performed.

(a) The project engineer shall certify the quality control testing of the synthetic liner ensuring that the material and workmanship meet the requirements of the approved engineering plans, reports, and specifications. Before installing a synthetic liner, the following information shall be available to the project engineer for approval:

1. Origin and identification of the raw materials used to manufacture the synthetic liner;

2. Copies of quality control certificates issued by the producer of the raw materials used to manufacture the synthetic liner; and

3. Reports of tests conducted to verify the quality of the raw materials used to manufacture the synthetic liner. Tests for specific gravity, melt flow index, and percent carbon black shall be performed using a method acceptable to the cabinet.

(b) The project engineer shall verify through appropriate documentation that the quality control testing of any synthetic rolls fabricated into blankets at the factory took place in accordance with the following requirements:

1. The synthetic liner was continuously inspected for uniformity, damage, imperfections, holes, cracks, thin spots, and foreign materials. Additionally, the synthetic liner shall be inspected for tears, punctures, and blisters. Any imperfections shall be immediately repaired and reinspected;

2. Nondestructive seam testing was performed on all fabricated seams over their full length using a test method acceptable to the cabinet; and

3. A destructive seam testing was performed on a minimum of two (2) samples per blanket. The samples shall be taken from extra material at the beginning or end of blanket seams such that the blanket is not damaged and the blanket geometry is not altered. The size of the sample taken shall be large enough to perform the required testing. An independent laboratory acceptable to the cabinet shall perform the required testing on the samples taken. If a sample fails a destructive test, the entire seam length shall be reconstructed or repaired using a method acceptable to the cabinet and retested using nondestructive seam testing over its full length using a test method acceptable to the cabinet.

(c) Quality assurance testing performed in the field under the supervision of the project engineer shall assure conformity of the synthetic liner installation with the engineering plans, reports, and

specifications submitted in accordance with the following requirements:

1. During the construction phase, the synthetic liner shall be inspected for uniformity, damage, and imperfections. The liner shall be inspected for tears, punctures, or blisters. Any imperfections shall be immediately repaired and reinspected;

2. All field seams shall be nondestructively tested in accordance with the procedures listed in this clause using a test method acceptable to the cabinet. The project engineer shall supervise all non-destructive testing; record the location, date, test unit number, name of tester, and results of all testing; inform the installer of any required repairs; and overlay all seams which cannot be nondestructively tested with the same synthetic liner. The seaming and patching operation shall be inspected by the project engineer for uniformity and completeness; and

3. Destructive testing shall be performed on the synthetic liner seam sections in accordance with the following requirements and using test methods acceptable to the cabinet. Seam samples for testing shall be taken as follows: a minimum of one (1) test per every 500 feet of seam length unless a more frequent testing protocol is agreed upon by the installer and project engineer; additional test locations may be determined during seaming at the project engineer's discretion; and all test locations shall be appropriately documented. The project engineer shall approve the sample size to be taken. The sample size shall be predetermined as being large enough to perform the required testing. An independent laboratory acceptable to the cabinet shall perform the required testing which shall include, as a minimum, testing for seam strength and peel adhesion using testing procedures acceptable to the cabinet. If a sample fails destructive testing the project engineer shall ensure that the seam is reconstructed between the location of the sample which failed and the location of the next acceptable sample; or the welding path is retraced to an intermediate location at least ten (10) feet from the location of the sample which failed the test, and a second sample is taken for an additional field test. If this second test sample passes, the seam shall then be reconstructed between the location of the second test and the original sampled location. If the second sample fails, this process shall be repeated. All acceptable seams shall lie between two (2) locations where samples passed the required test procedures of this section and include one (1) test location along the reconstructed seam.

Section 6. Primary Liner System. The liner shall be designed using the following specifications:

- (1) A thirty-six (36) inch thick low permeability soil layer having a remolded coefficient of permeability of  $1 \times 10^{-7}$  centimeters per second and compacted to a minimum of ninety-two (92) percent standard proctor density;

- (2) A sixty (60) mil thick synthetic liner having a maximum coefficient of permeability of  $1 \times 10^{-12}$  centimeters per second and not adversely affected by the leachate or loading from the operational landfill;

- (3) A leachate collection and removal system consisting of a twelve (12) inch thick granular material layer with a leachate collection pipe network. This collection system shall be designed to achieve a maximum hydraulic head on the primary composite liner no greater than twelve (12) inches. The granular material shall have a minimum coefficient of permeability of  $1 \times 10^{-2}$  centimeters per second. The physical and chemical properties of the granular material and pipe shall not be adversely affected by the loads or leachate generated by the operations of the landfill. Alternate materials proposed to function as a substitute for the granular soil layer shall be demonstrated to be equivalent in performance for leachate drainage and load bearing properties; and

- (4) The leachate collection system shall contain a perforated piping system capable of removing leachate from the top surface of the low permeability solid component, and conveying it to a collection point. The drainage system shall meet the following requirements:

- (a) Main leachate collection pipes shall have a minimum diameter of eight (8) inches and shall be designed to withstand static and dynamic loads that may be encountered;

- (b) The sheet flow drainage distances to the lateral drainage pipes shall not exceed fifty (50) feet;
  - (c) The lateral pipes shall be installed primarily perpendicular to flow;
  - (d) The minimum diameter of lateral perforated pipes shall be four (4) inches and shall be designed to withstand static and dynamic loads that may be encountered. The materials used shall at a minimum conform to the specifications for ASTM schedule eighty (80) pipe;
  - (e) The minimum slope for the piping system shall be one (1) percent;
  - (f) The leachate collection tank shall be a minimum of 1,000 gallons. Additional capacity shall be provided to store leachate for a minimum of fifteen (15) days production at peak production rates during operation and closure;
  - (g) The method of leachate disposal shall be described. When it is discharged to the sediment structure, a treatment plant is proposed or other method of discharge is proposed, the KPDES permit shall reflect this provision. When an off-site wastewater treatment plant is used, the applicant shall provide written documentation showing the acceptance of the waste. The criteria for disposal at the wastewater treatment plant shall be stated. The leachate collection system shall have a method to measure the quantity of leachate managed at the site;
  - (h) The leachate collection pipe system shall be designed to allow internal inspection, cleaning and maintenance; and
  - (i) The maximum design head of the leachate collection system shall be one (1) foot.
- (5) A geosynthetic filter fabric or other suitable material shall be placed above the drainage layer to prevent clogging.

Section 7. Slope Considerations. (1) For bottom slopes of less than or equal to ten (10) percent, the owner or operator shall have a liner system meeting the requirements of Section 1 of this administrative regulation.

(2) For bottom slopes of ten (10) to twenty-five (25) percent, the owner or operator shall have a liner system meeting the requirements of Section 2(3) of this administrative regulation, except that the owner or operator may replace the granular soil layers in the leachate collection and hydraulic relief systems with synthetic drainage netting.

(3) For bottom slopes of more than twenty-five (25) percent, the thickness of the soil required in Sections 2(3)(a) and (6)(1) of this administrative regulation shall be reduced by no more than twelve (12) inches.

Section 8. Final Cap System. At a minimum the final cap shall consist of a layered system. Each layer shall have the same slope of between five (5) and twenty-five (25) percent. The components, listed from bottom to top, are:

- (1) A filter fabric or other material approved by the cabinet;
- (2) A twelve (12) inch sand gas venting system with a minimum hydraulic permeability of  $1 \times 10^{-3}$ ;
- (3) A filter fabric or other material approved by the cabinet;
- (4) An eighteen (18) inch clay layer with a maximum permeability of  $1 \times 10^{-7}$  centimeters per second;
- (5) For areas of the final cap with a slope of less than fifteen (15) percent, a twelve (12) inch drainage layer with a minimum permeability of  $1 \times 10^{-3}$  centimeters per second; and
- (6) A thirty-six (36) inch vegetative soil layer.

Section 9. Final Cap System Specifications. The specifications for final cap component layers are:

- (1) A low permeability clay layer listed in Section 8(4) of this administrative regulation shall be compacted to a minimum of ninety-two (92) percent of the standard proctor density;
- (2) A drainage layer specified in Section 8(5) of this administrative regulation shall be compacted

to a minimum of eighty-five (85) percent of the standard proctor density. Field tile drainage shall be specified as necessary to relieve water captured by this drainage layer;

(3) A vegetative soil layer as specified in Section 8(6) of this administrative regulation shall be sufficient to sustain vegetative growth and prevent root penetration of the underlying layers. A thicker layer may be required by the cabinet to properly retain moisture or meet closure care requirements.

(4) Drainage berms of at least one (1) foot in height or two (2) feet in width shall be placed at the following intervals for the following slopes:

(a) 150 feet at greater than ten (10) percent slope;

(b) 200 feet at slope between five (5) and ten (10) percent. In lieu of drainage berms, the owner or operator may substitute a design with a horizontal terrace of at least fifteen (15) feet width on the slope for every twenty-five (25) feet maximum rise in elevations on the slope. The slope of the terrace shall be five (5) percent into the fill and drainage ditches shall be designed for each terrace to convey precipitation flows. The maximum slope between terraces shall not exceed twenty-five (25) percent; or

(c) The applicant shall may adjust the drainage berm specifications with design calculations based upon characteristics of soils and cover.

(5) A synthetic liner with a minimum thickness of forty (40) mils and a maximum coefficient of permeability of  $1 \times 10^{-12}$  centimeters per second may be substituted for the low-permeability soil cover in Section 8(4) of this section.

(6)(a) The final cover shall be revegetated.

(b) The soil-water pH shall be adjusted and the soil fertilized based upon current soil test results.

(c) The seed bed shall be prepared and temporary nurse crops and permanent grasses planted in accordance with the approved closure plan within thirty (30) days of completion of final cover grading.

(d) The owner or operator shall repeat the above as necessary to achieve permanent vegetation.

(e) Erosion controls shall be addressed in the closure plan and constructed as required. All slopes over three (3) percent shall have controls applied at the time of seeding.

(f) The owner or operator shall inspect all areas and perform maintenance and revegetation. At a minimum, the site shall be initially inspected according to this table:

Seeding Date	Follow-up Inspection Date	Complete Revegetation By
Aug. 16-Oct. 15	April 1	June 15
Oct. 16-Mar. 15	June 1	June 30
Mar. 16-Jun. 15	September 1	October 15
Jun. 16-Aug. 15	October 1	October 30

After the initial inspection, follow-up inspections shall be made on April 1, and September 1, with revegetation completed by June 15 and October 15.

(g) After one (1) year, all areas larger than 100 square feet with less than forty (40) percent vegetation shall be tested to determine required revegetation, which shall be completed by September 30.

Section 10. Structural Integrity of Cap and Liner. The design engineer shall analyze the structural

integrity of the site, the subbase, each component of the composite liner, each component of the final cover, the composite liner system and the final cap as a system. Modifications to the design shall be provided where necessary, to achieve a minimum factor of safety of two (2) for the subbase, one and one-fourth (1.25) for the structural design of the facility liner components, and one and one-half (1.5) for the final cover system. Synthetic liner material and structural synthetic materials shall be designed for a maximum elongation of ten (10) percent.

Section 11. Alternative Specifications. Alternative specifications may be used only after approval by the cabinet upon a demonstration by a qualified registered professional engineer that they shall result in performance with regard to safety, stability and environmental protection equal to or better than that resulting from designs complying with the specifications of this administrative regulation. (16 Ky.R. 1776; Am. 2211; 2374; eff. 5-8-90.)